Chapter 12

Machine Design Modification Strategies

Sometimes design errors occur such that one or more torsional natural frequencies have inadequate separation margins from the main torsional forcing frequencies of concern. As discussed previously, the frequencies of concern are often 60 and 120 Hz in the case of 60-Hz power generation systems.

There are two main turbomachinery detuning approaches.

1. The first approach, which is often the easiest to apply, is to lower or raise the offending torsional natural frequency, by adding or reducing inertias, respectively, at axial locations which are torsionally responsive in that mode. Examination of the calculated or measured mode shape is helpful in determining the machine locations that have high relative motion. Placement of inertia at an axial location that is at or close to an antinode will have the most effect, whereas placement of inertia at a nodal point will have zero effect. Possibilities for changing inertia include

- Adding a flywheel
- Shrinking a ring on the outside diameter of a coupling
- Replacing a rotating component with one of different density having suitable other properties
- Replacing a shrunk on component that can be removed easily with one of different size

In each case it is necessary to investigate that no performance or machine interface problems would result from the configuration change. For example, if a component were modified resulting in a weight increase, it would be important to check that mating components can sustain the increase in centrifugal load.

2. The second approach is to change the stiffness of the system. Examination of the mode shape to find sections of the machine that are undergoing the most relative twist would also be helpful in this case. In these areas it may be possible to machine off some material to lower the stiffness and the natural frequency. For some rotors it may be possible to cut off a shaft extension and bolt on a new one of modified dimensions. In planning such stiffness modifications, caution must be exercised because, for example, removing material to reduce stiffness and natural frequency will also lower the inertia tending to negate some of the frequency reduction benefit.

In the case of higher-order rotor-bucket system modes where the primary concern is turbine blade fatigue failures, detuning these modes from 120 Hz (for a 60-Hz transmission system) by just a fraction of a hertz may be sufficient in some cases to dramatically improve vibration performance. This is because of the very light damping in these modes and the needle-shaped resonance peaks. The required level of detuning may often be achieved in these modes by modifying the rotor system by the strategies explained earlier and/or by employing a modified blade or blade attachment design.

It should also be noted that even if natural frequency calculations for a given machine turn out to be of poor accuracy for an unexplained reason, using that same analytical model to calculate the percentage change in a natural frequency as a result of a modification is likely in most cases to give acceptable guidance. This, of course, would be untrue if there were gross errors in parts of or the entire mathematical model.